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IMPROVED DYNAMICS FOR DROPLET ACTUATION BY STRATEGICALLY USING TRIANGULAR COPLANAR ELECTRODES IN DIGITAL MICROFLUIDIC SYSTEM

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Electrowetting on dielectric (EWOD) is an emerging technique for manipulation of liquid droplet by application of electric field over an array of coplanar electrodes known as Digital Microfluidic (DMF) platform. DMF platform incorporated with EWOD technology allow compact fabrication, reduced reagent consumption, smaller analysis time along with efficiency, programmability and portability which is applied to different field of studies like lab-on-chip, polymer chain reaction (PCR), DNA hybridization and many more[1]. In developing such a DMF based platform various device optimizations are required of which optimization in the geometry of the coplanar electrodes is noteworthy. Thus, various research groups has studied different electrode design to establish the surface energy gradient for improvement of droplet velocity and dynamic parameters [2]. In this paper, we have introduced triangular coplanar interdigited electrode array with zigzag motion of micro-droplet with improved velocity than those of the conventionally used square electrode.

The method basically follows the Young's-Lippmann equation[3], where the wetted contact angle arises on the portion of the droplet (in this case 1mM KCl) in contact with activated electrode, giving rise to electrocapillary force on that direction at three phase contact line (TPCL) region . This TPCL can be strategically modified by various designs to increase its length for faster manipulation of liquid droplet over DMF platform by creating improvement in electrocapillary force magnitude. Another strategy which might affect droplet actuation dynamics is reducing the distance traversed by a droplet after single switching, thus improving the transfer frequency of the droplet. This design of interdigited coplanar triangular electrodes cover almost both the factors, with consistent changing contact line creating improvement in velocity as well as transfer frequency is also achieved. It consists of nine interdigited electrodes with electrode dimension of 1.5 mm and having interelectrodes gap of 60μm as shown in figure 1.

An indigenous switching setup is prepared with Arduino Uno as microcontroller by keeping the switching rate at 1.5 sec per switching for droplet actuation as schematically depicted in figure 1. Videos are captured for droplet actuation with zigzag motion over fabricated DMF platform as shown in figure 2. An open source software 'Tracker' is used to measure the experimental droplet velocities at different operating voltages as shown in figure 3. The experimental data for square electrodes for comparison are taken from similar kind of research performed by other research group[4]. The average velocities for this fabricated DMF platform are compared with square electrode based DMF platform as shown in the inset of figure 3. Finally, the transfer frequencies are evaluated with 15% improvement in case of triangular coplanar electrodes in table 1. This kind of improved dynamic characteristics DMF platform might helpful to perform rapid chemical or biochemical reactions in a single lab-on-chip platform.

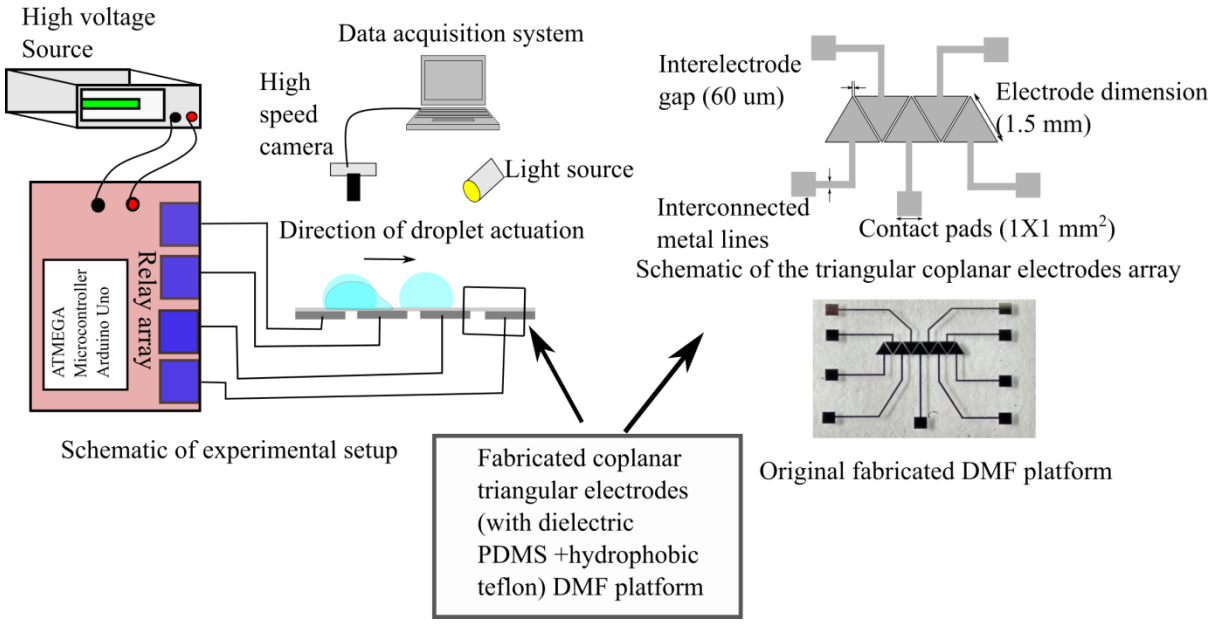
High voltage Source
Data acquisition system
High speed camera
Light source
Direction of droplet actuation
ATMEGA Microcontroller Arduino Uno
Relay array
Schematic of experimental setup
Fabricated coplanar triangular electrodes (with dielectric PDMS +hydrophobic teflon) DMF platform
Interelectrode gap (60 um)
Electrode dimension (1.5 mm)
Interconnected metal lines
Contact pads (1X1 mm²)
Schematic of the triangular coplanar electrodes array
Original fabricated DMF platform

Figure 1: Schematic of the experimental setup along with the fabricated coplanar triangular electrode design and original image of DMF platform

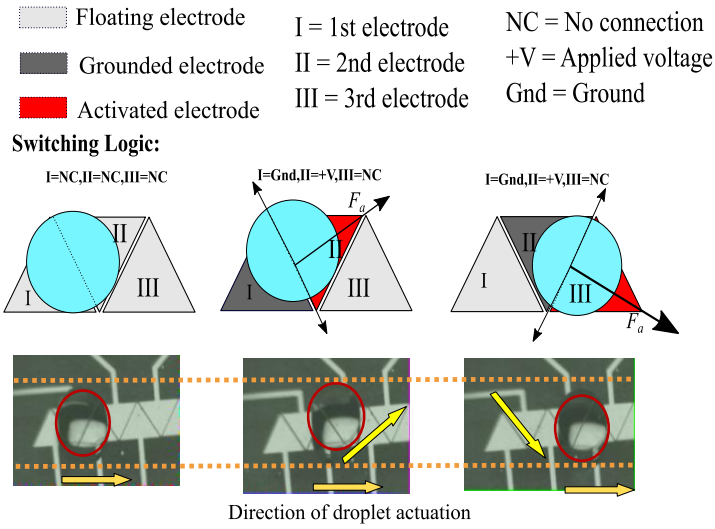

Figure 2: Schematic and original zigzag droplet actuation over

Voltage (V)	Triangular electrode (present study) (t_{tr}) (s)	Square electrode (t_{tr}') (s)	% of variation
200	0.8660	1	15.471
250	0.7177	0.8287	15.463
300	0.4921	0.5682	15.464
350	0.4374	0.5051	15.477

Table 1: Transfer frequencies comparison at different applied voltages.

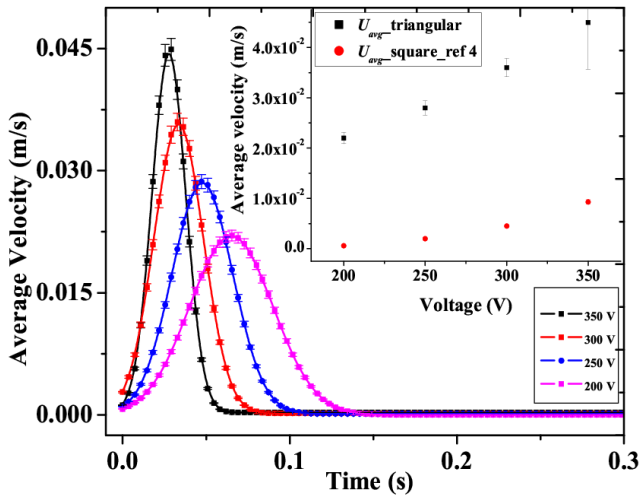

Figure 3: Transient velocity profile of droplet over triangular electrodes array; comparison of velocity of triangular and square electrode array (inset).

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